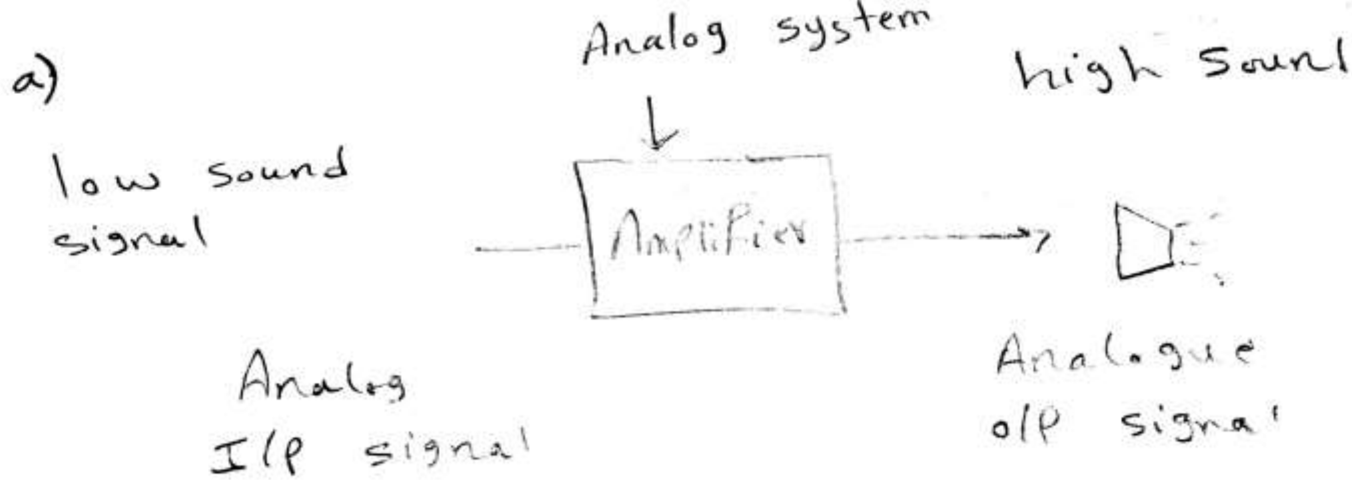
Digital signal Processing

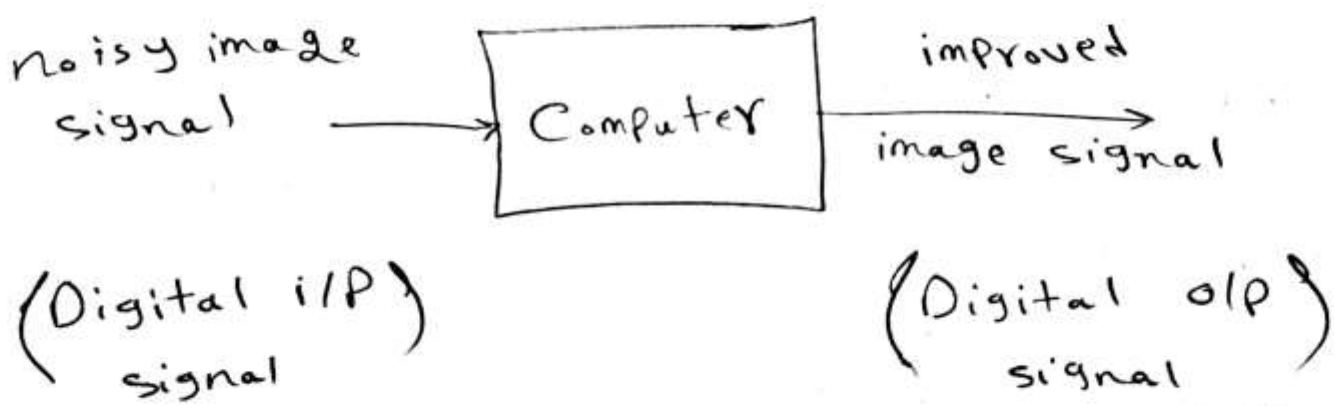
"DSP"

Signal Processing

Analog ~~Sys~~ | Digital

a)





Digital

→ Advantage of DSP

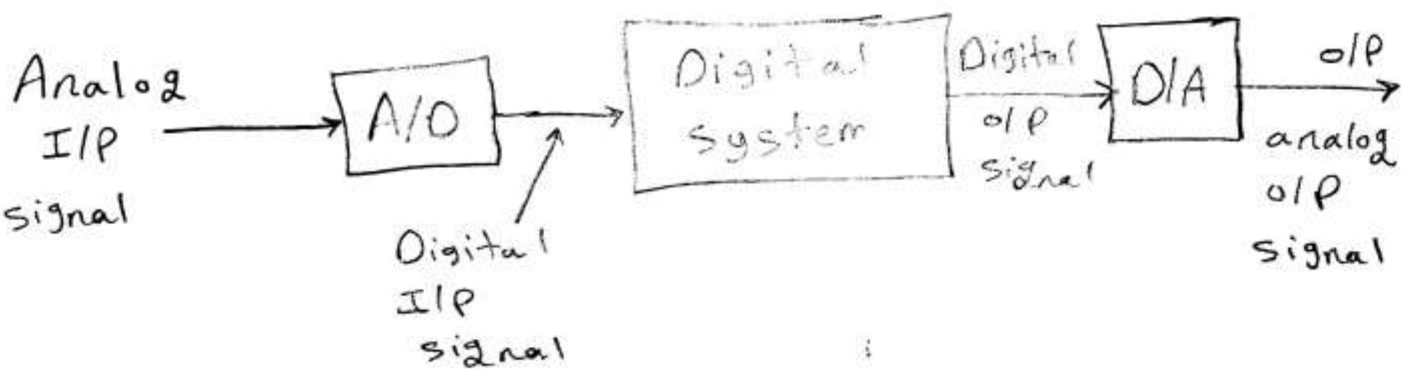
① more flexible.

② more Accurate.

③ easy to store.

④ easy to update.

* The Basic of DSP

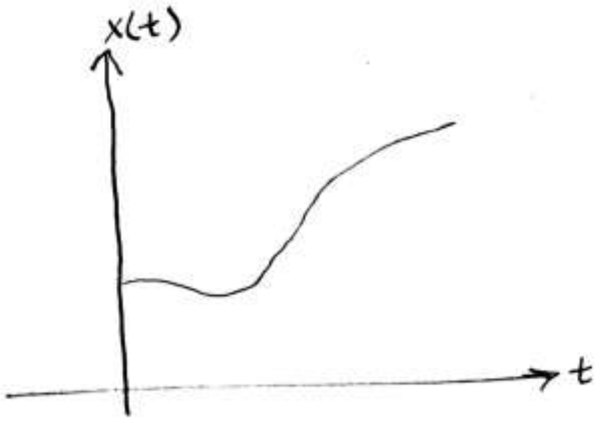


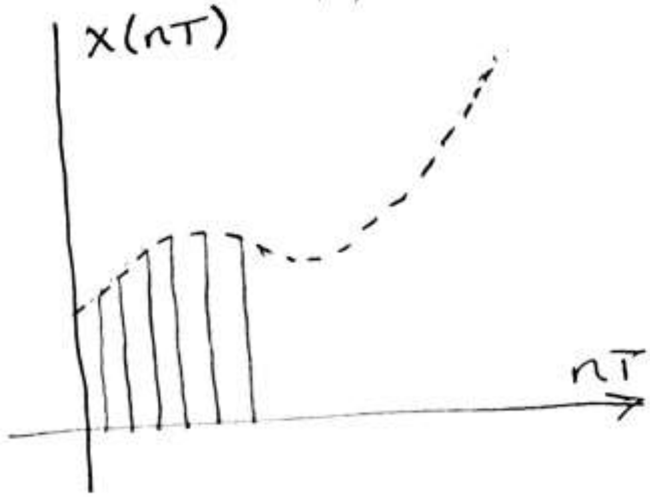
A/D → Analog to Digital Converter.

D/A → Digital to Analog Converter.

$\underline{\underline{A/D}} \equiv$ Sampler

Analog → Digital





$T \Rightarrow$ Sampling time

$n \Rightarrow$ Sampling no. $(n = 0, 1, 2, 3, 4, \dots)$

معدل التقطيع

← الـ (Sampler) لو زاد هيزيد معدل التقطيع وهيقدر يعطي إشارة شبيهه تماماً وتزيد الـ (Accuracy) ولكنه سيحتاج إمكانيات أعلى.

~~Assume T~~

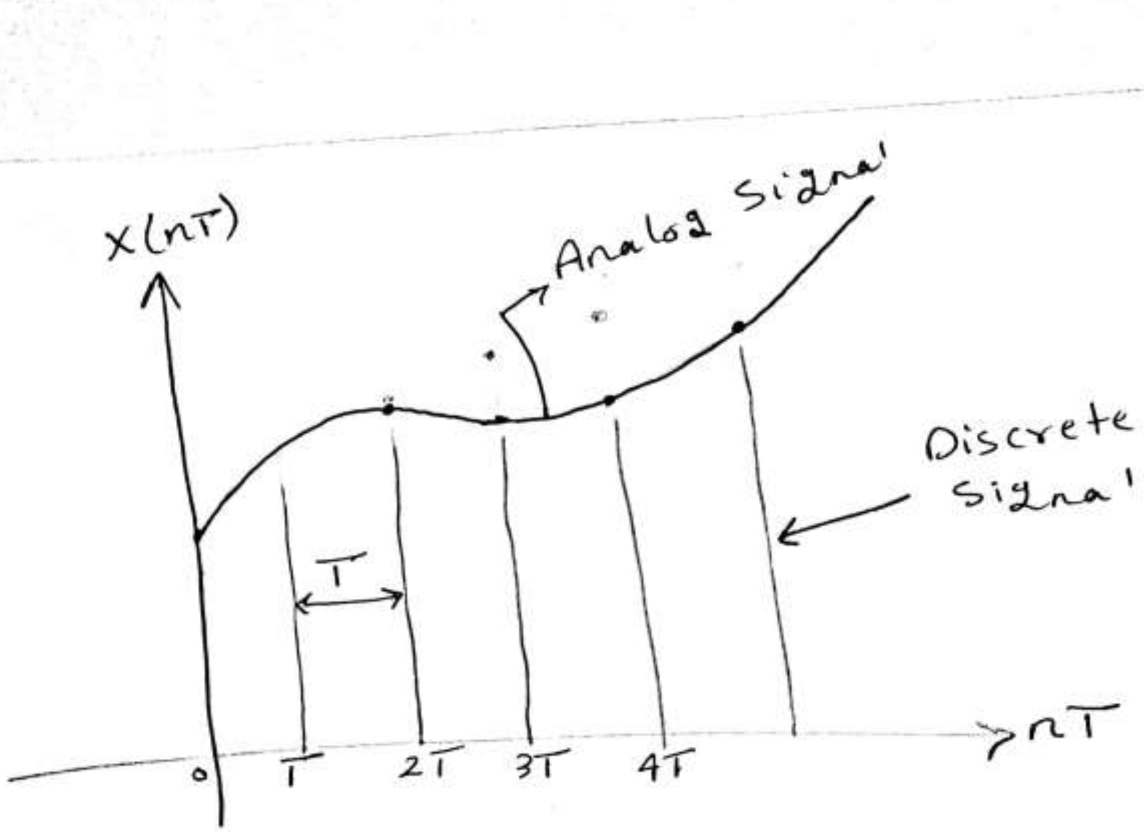
→ Assume $T = 1$

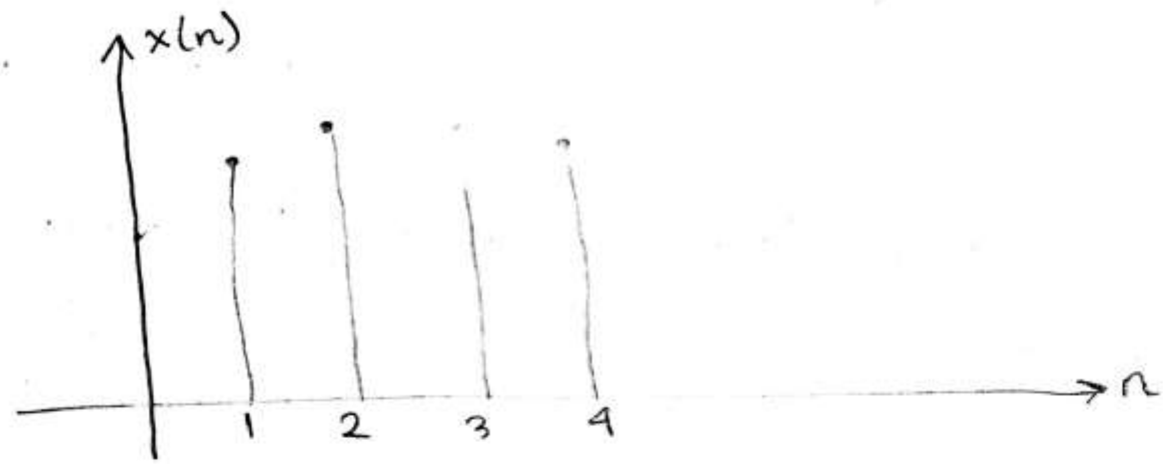
$$x(nT) = x(t)\Big|_{t = nT}$$

at: $T = 1$

$$\bullet\ x(n) = x(t)\Big|_{t = n}$$

sampling no.





* Common discrete signals (sequences)

① unit sample signal (impulse)

$$\delta(n) = \begin{cases} 1 & n = 0 \\ 0 & \text{otherwise} \end{cases}$$

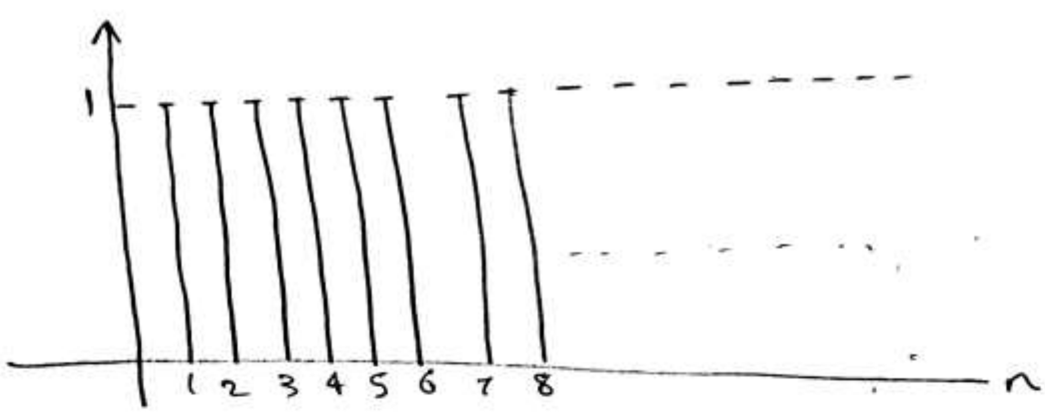
$$\delta(n) = \{\ldots, 0, 0, 0, \underset{\uparrow}{1}, 0, 0, 0, \ldots\}$$

← معروف إن السهم ده بيعرفك إن (n=0) والأرقام
على يمينها تكون (1، 2، 3، ...) وعلى اليسار بالسالب (-1، -2، ...)

$\uparrow \Rightarrow$ indicate $n = 0$

② unit step signal

$$u(n) = \begin{cases} 1 & n \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

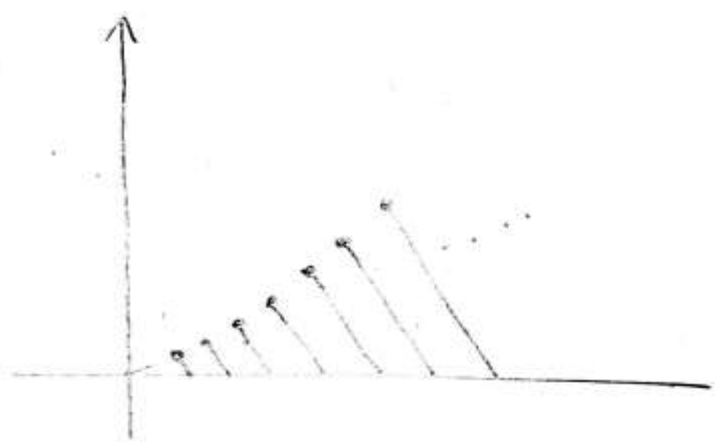


$$u(n) = \{\cdots 0, 0, 0, \underset{\uparrow n=0}{1}, 1, 1, 1, 1, 1 \cdots\}$$

$$= \{\underset{\uparrow n=0}{1}, 1, 1, \cdots\cdots\}$$

③ unit ramp signal:-

$$u_r(n) = \begin{cases} n & n \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

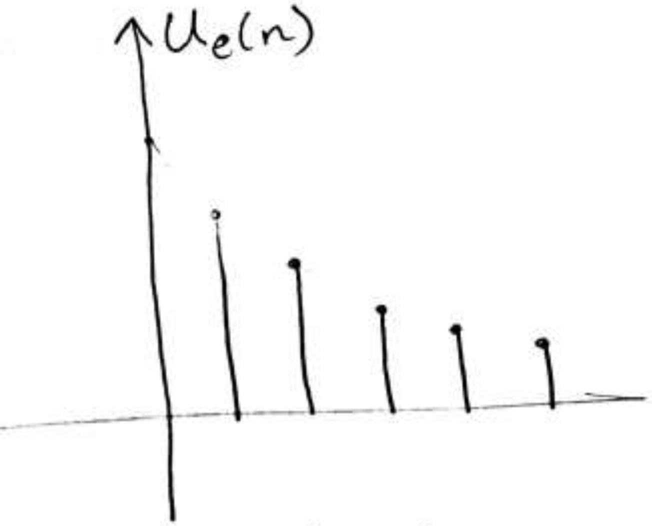


$$u_r(n) = \{\underset{\uparrow n=0}{0}, 1, 2, 3, 4, \cdots\}$$

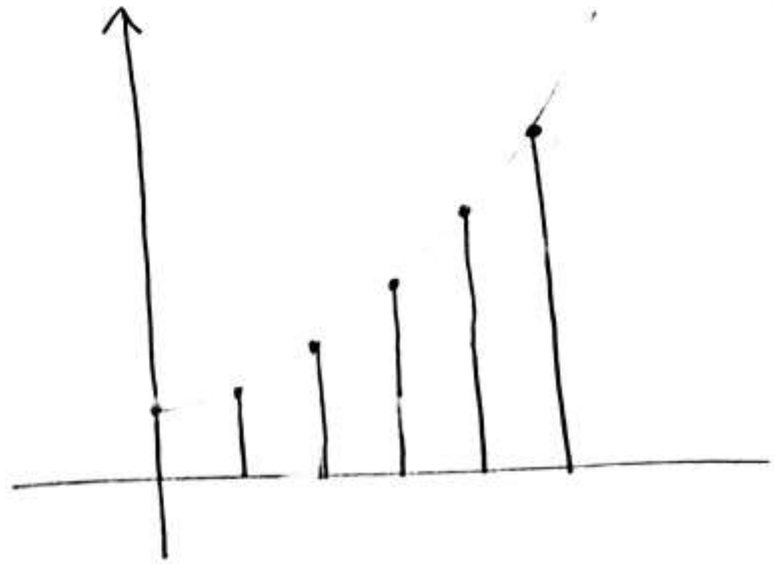
④ exponential signal:-

$$u_e(n) = \begin{cases} a^n & n \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

$$u_e(n) = \{\underset{\uparrow n=0}{1}, a, a^2, a^3, \cdots\}$$



$1 < a < 0$



$a > 1$

Ex:- given the following sequence:-

$$x(n) = \left\{ \tfrac{1}{3}, \tfrac{1}{2}, -1, \underset{n=-1}{0}, \underset{n=0}{1}, \underset{n=1}{1}, \underset{n=2}{2} \right\}$$

ⓐ sketch $x(n)$

ⓑ find $x(1)$, $x(2)$, $x(3)$, $x(-1)$, $x(-2)$

$x(-3)$, $x(-4)$

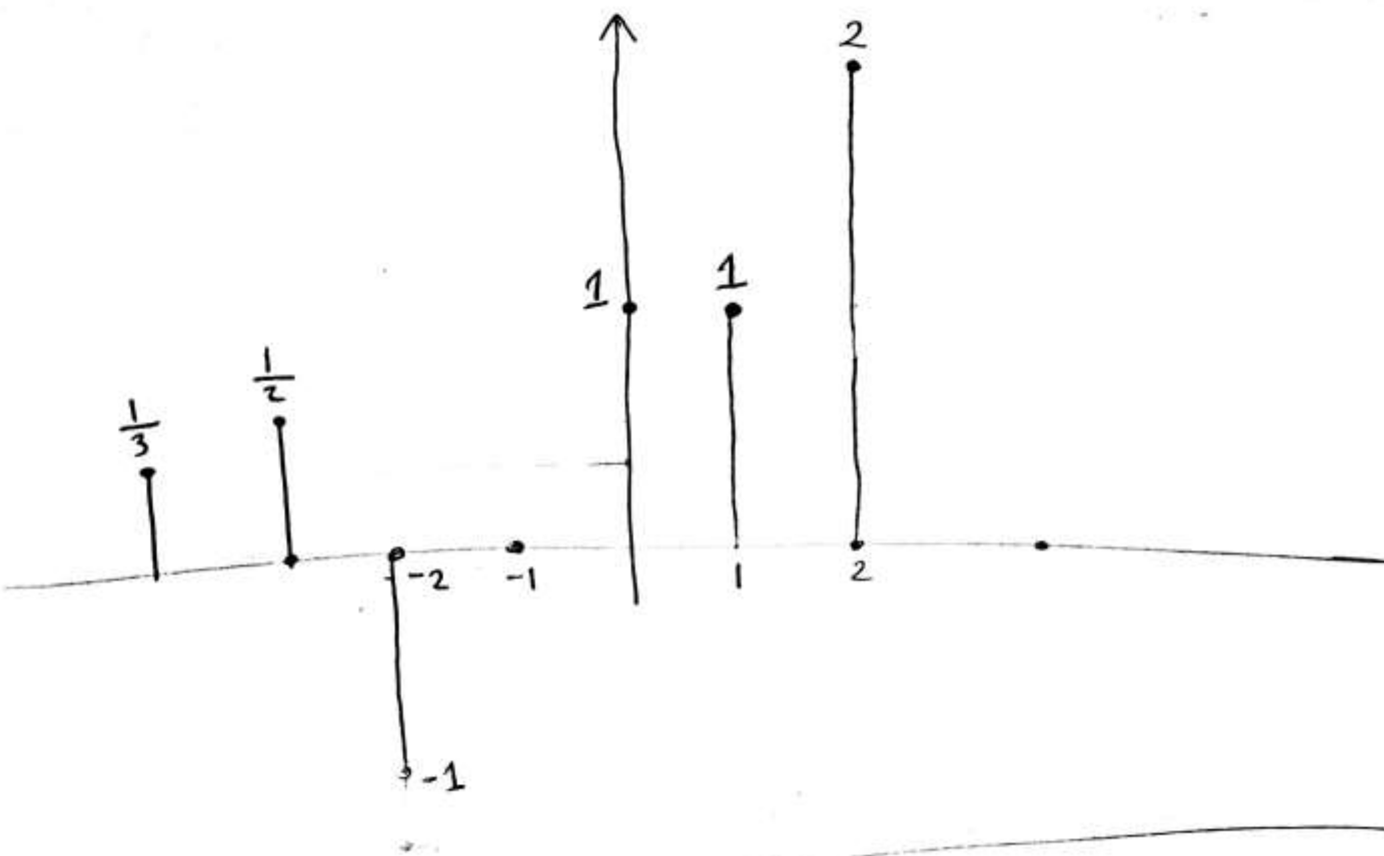
Sol

$x(1) = 1$ $\qquad$ $x(-1) = 0$

$x(2) = 2$ $\qquad$ $x(-2) = -1$

$x(3) = 0$ $\qquad$ $x(-3) = \frac{1}{2}$

$x(-4) = \frac{1}{3}$



$\boxed{Ex}$ find $\sum_{K=-\infty}^{n} \delta(K)$

$$\sum_{K=-\infty}^{n} \delta(K) = \cdots + \delta(-2) + \delta(-1) + \delta(0) + \delta(1) + \cdots \delta(n)$$

$$\left.\begin{array}{l} n=0 \Rightarrow x(0)=1 \\ n=1 \Rightarrow x(1)=1 \\ n=2 \Rightarrow x(2)=1 \end{array}\right\} \Rightarrow x(n) = \sum_{n=-\infty}^{n} \delta(K)$$

$$= u(n)$$

↳ unit-step

$\boxed{Ex}$

$\boxed{\text{find}}$ $x(n) = \sum_{K=0}^{\infty} \delta(n-K)$

$$x(n) = \delta(n) + \delta(n-1) + \delta(n-2) \cdots\cdots$$

Notice

$\delta(n) = 1 \Big|_{n=0}$ you can consider it

$\delta(n-1) = 1 \Big|_{n=1}$ unit step

$\delta(n-2) = 1 \Big|_{n=2}$ $x(n) = u(n)$

→ The main operations on discrete signals :-

① shifting operation (delay, Advance)

② folding (reflection) operation.

③ Add operation :

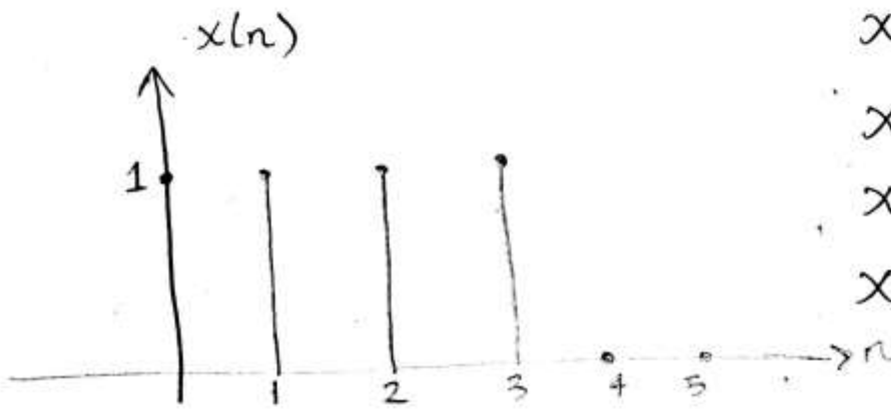
④ multipliacation operation

$\boxed{EX}$ $x(n) = \{1, 1, 1, 1\}$

<u>Find</u> $y_1(n) = x(-n)$, $y_2(n) = x(n-1)$

$y_3(n) = x(n+1)$, $y_4(n) = 2\,x(n)$

$y_5(n) = x(n-1) + x(n+1)$



$x(0) = 1$

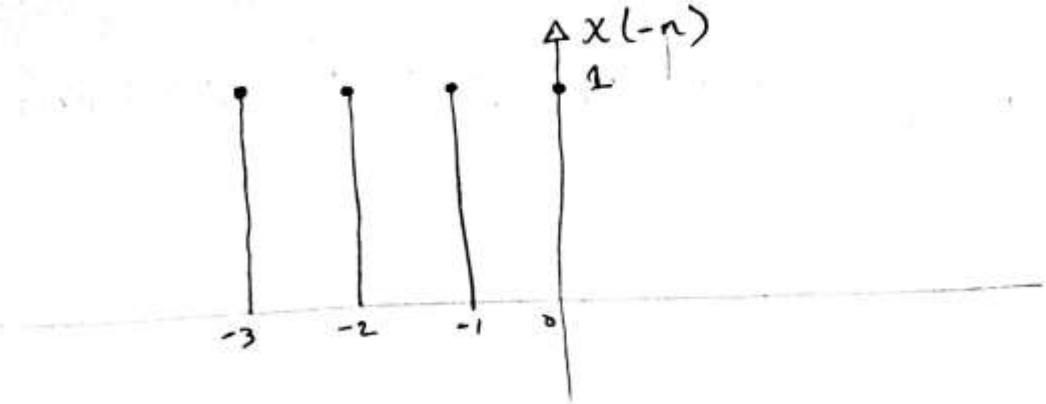
$x(1) = 1$

$x(2) = 1$

$x(3) = 1$

$\boxed{1}$ $y_1(n) = x(-n)$

$n=0 \Rightarrow y_1(0) = x(0) = 1$	$n=-1 \Rightarrow y_1(-1) = x(1) = 1$
$n=1 \Rightarrow y_1(1) = x(-1) = 0$	$n=-2 \Rightarrow y_1(-2) = x(2) = 1$
$n=2 \Rightarrow y_1(2) = x(-2) = 0$	$n=-3 \Rightarrow y_1(-3) = x(3) = 1$
مفيش داعي نكمل لأنه الباقي بأصفار.	$n=-4 \Rightarrow y_1(-4) = x(4) = 0$



→ It is a folding operation.

(b) $y_2(n) = x(n-1)$

$n=0 \Rightarrow y_2(0) = x(-1) = 0$

$n=1 \Rightarrow y_2(1) = x(0) = 1$

$n=2 \Rightarrow y_2(2) = x(1) = 1$

$n=3 \Rightarrow y_2(3) = x(2) = 1$

$n=4 \Rightarrow y_2(4) = x(3) = 1$

$n=5 \Rightarrow y_2(5) = x(4) = 0$

$n=-1 \Rightarrow y_2(-1) = x_2(-2) = 0$

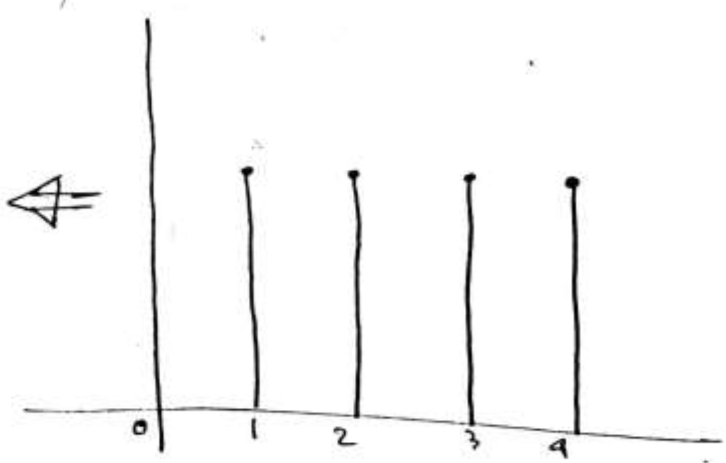
$n=-2 \Rightarrow y_2(-2) = x_2(-3) = 0$

shift to right by one sample

⇓

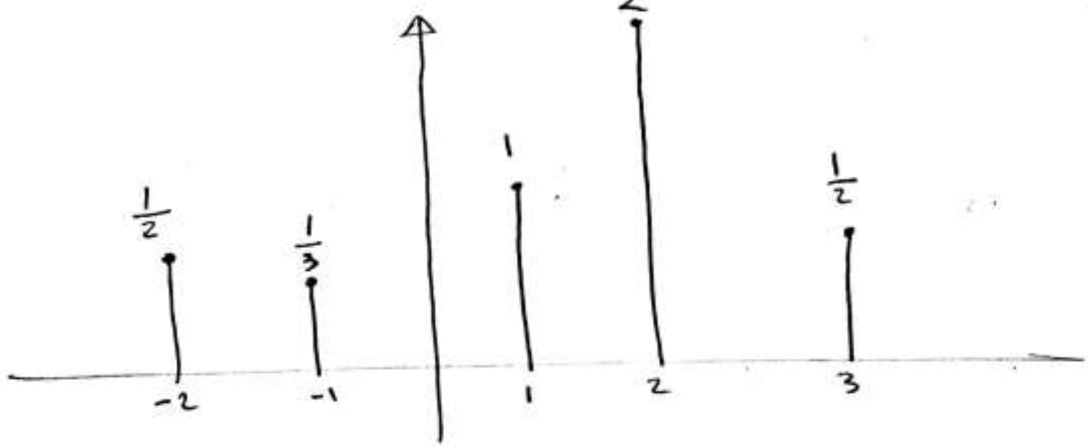
Delay operation

(Delay by one sample)

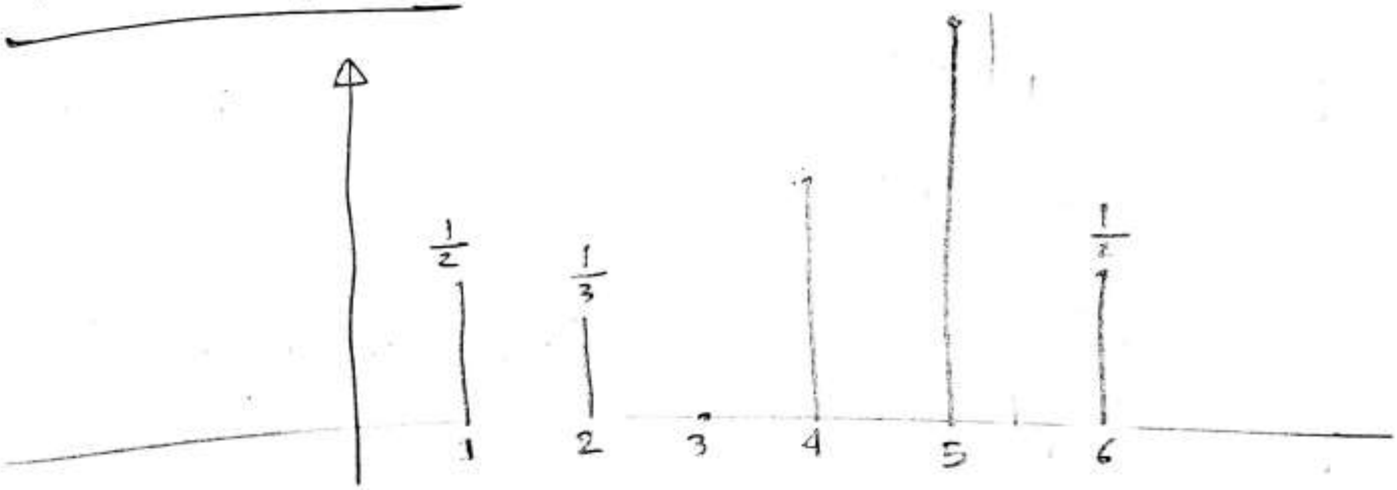


$x(n-k) \Rightarrow$ shift to right by k-samples.

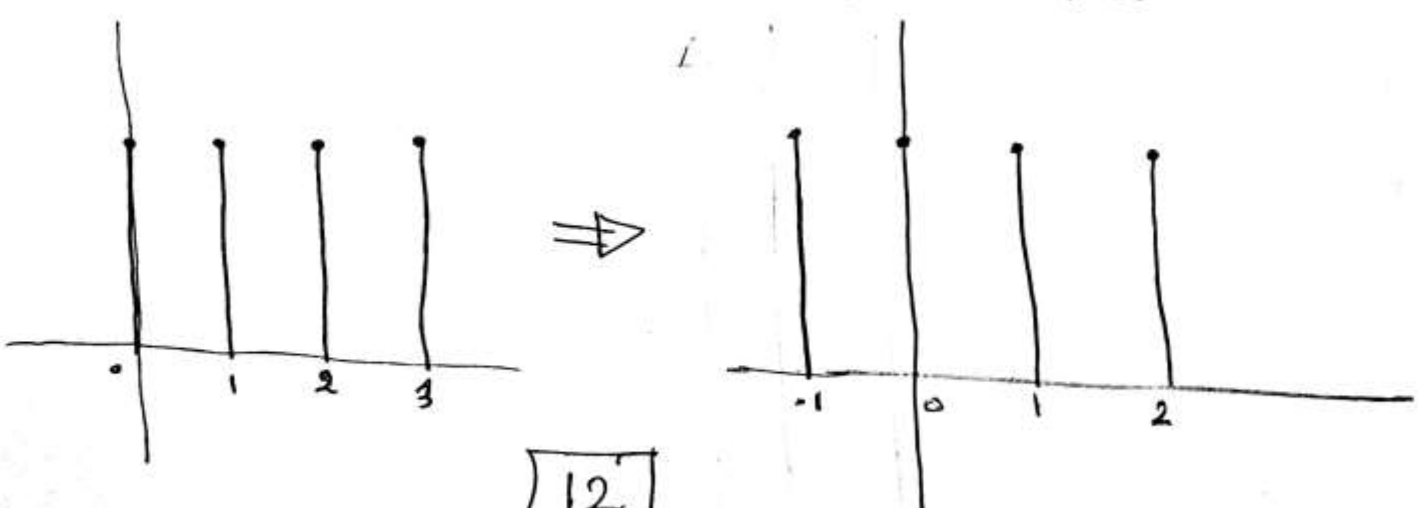
$\boxed{Ex}$



find $x(n-3)$

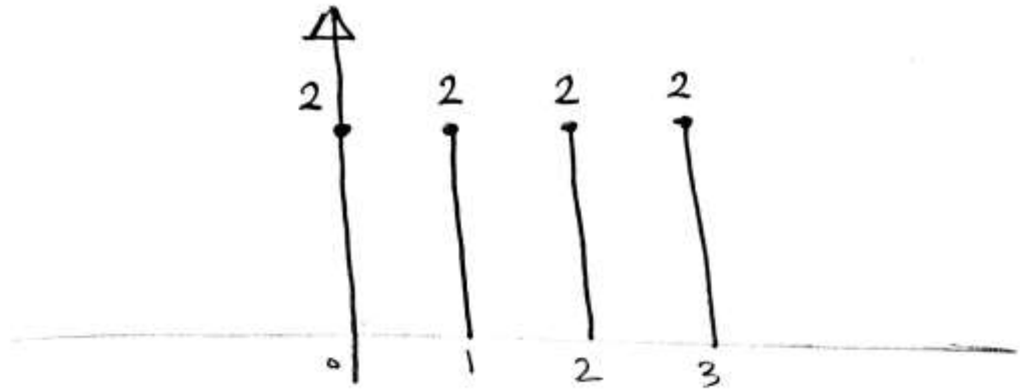


③ $y_3(n) = x(n+1) \rightarrow$ shift to left by one sample.

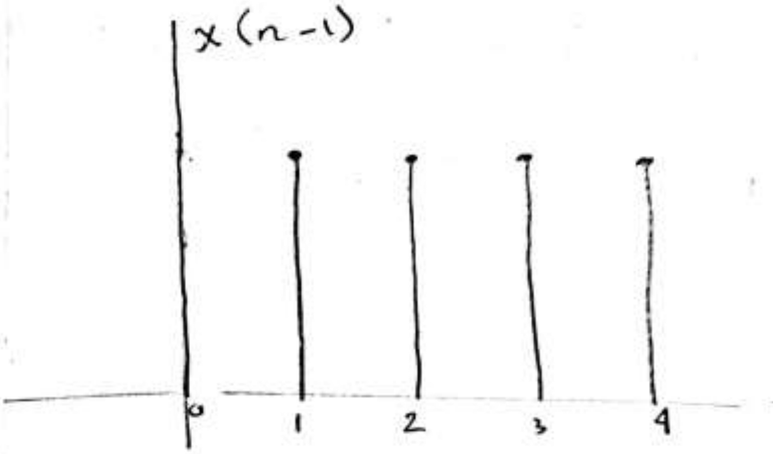


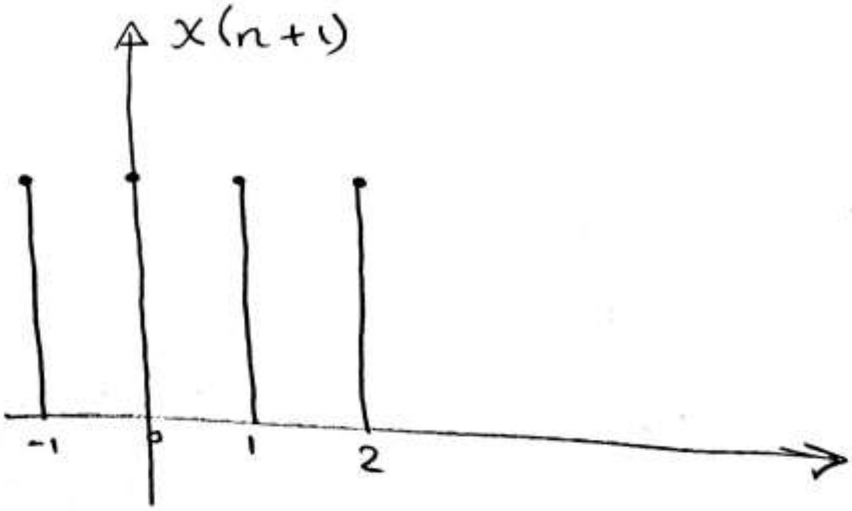
$x(n+K) \longrightarrow$ shift to left by K-samples.

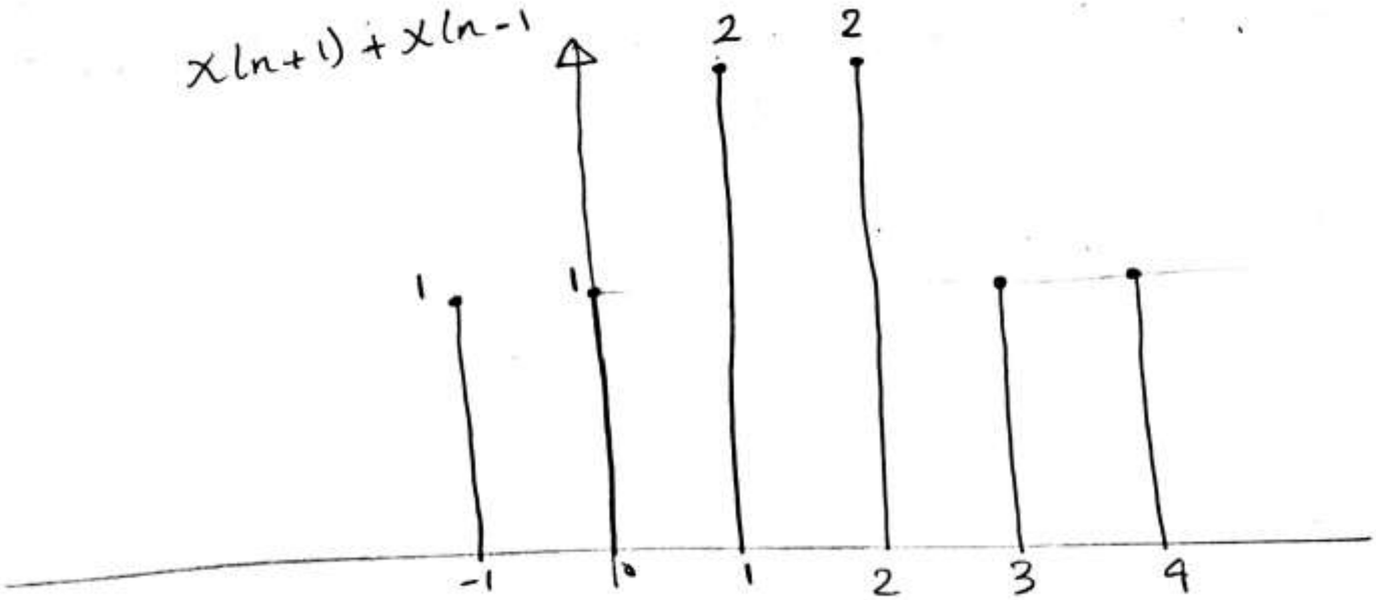
④ $y_4(n) = 2\,x(n)$



⑤ $y_5(n) = x(n+1) + x(n-1)$





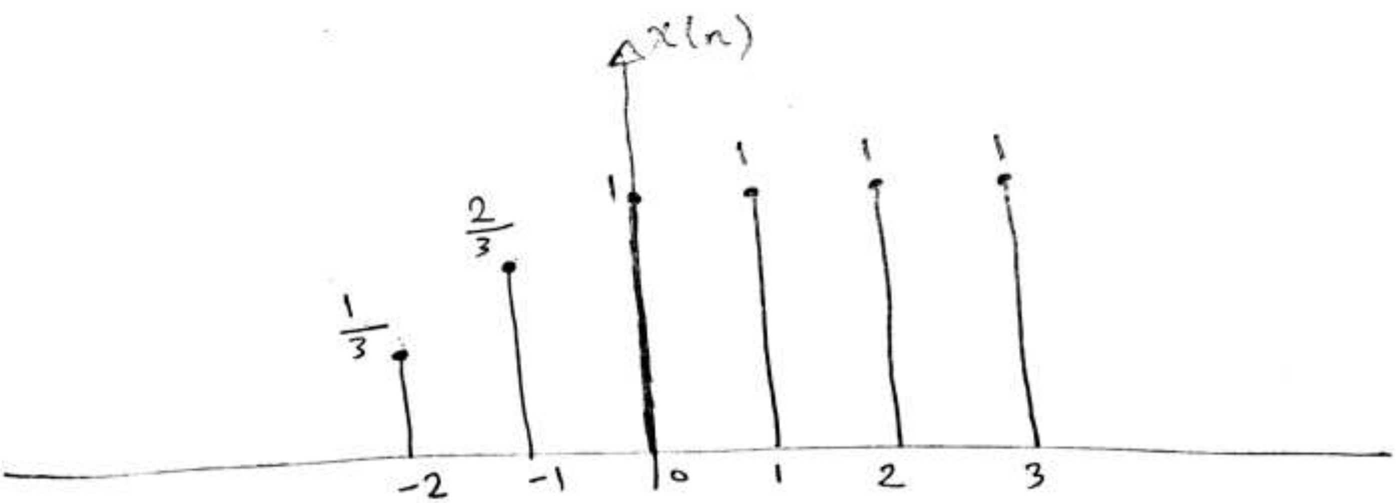


$\boxed{Ex}$ $x(n) = \{ \frac{1}{3}, \frac{2}{3}, \underset{\uparrow_{n=0}}{1}, 1, 1, 1 \}$

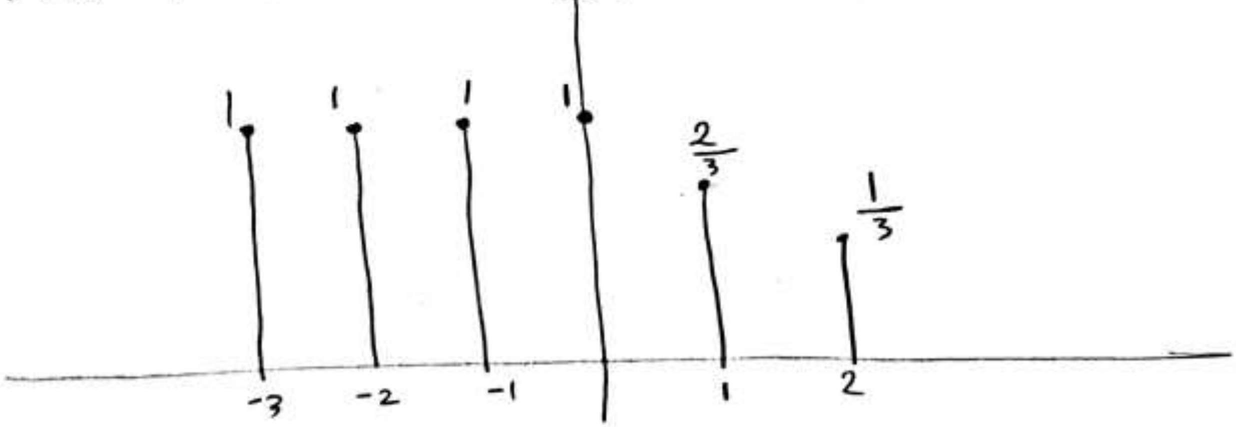
1- sketch $x(n)$

2- fold $x(n)$ and then delay by 4 samples.

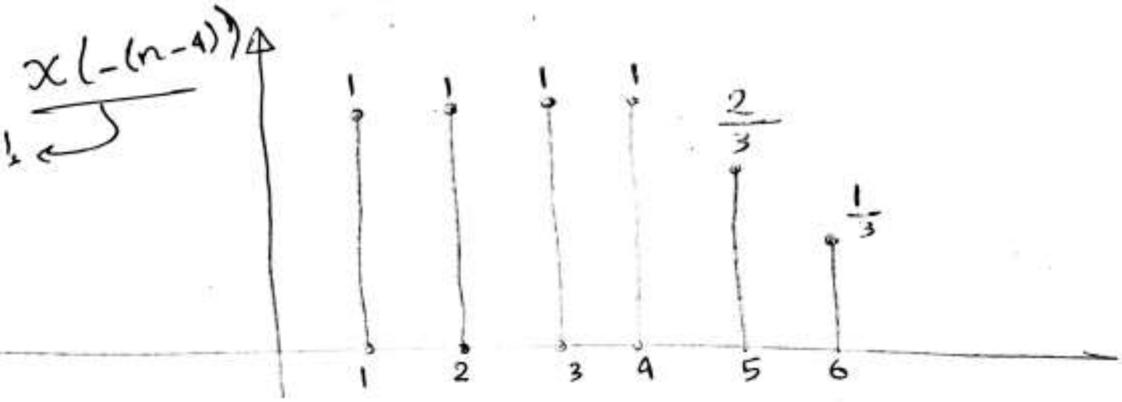
3- Delay $x(n)$ by 4 samples then fold.



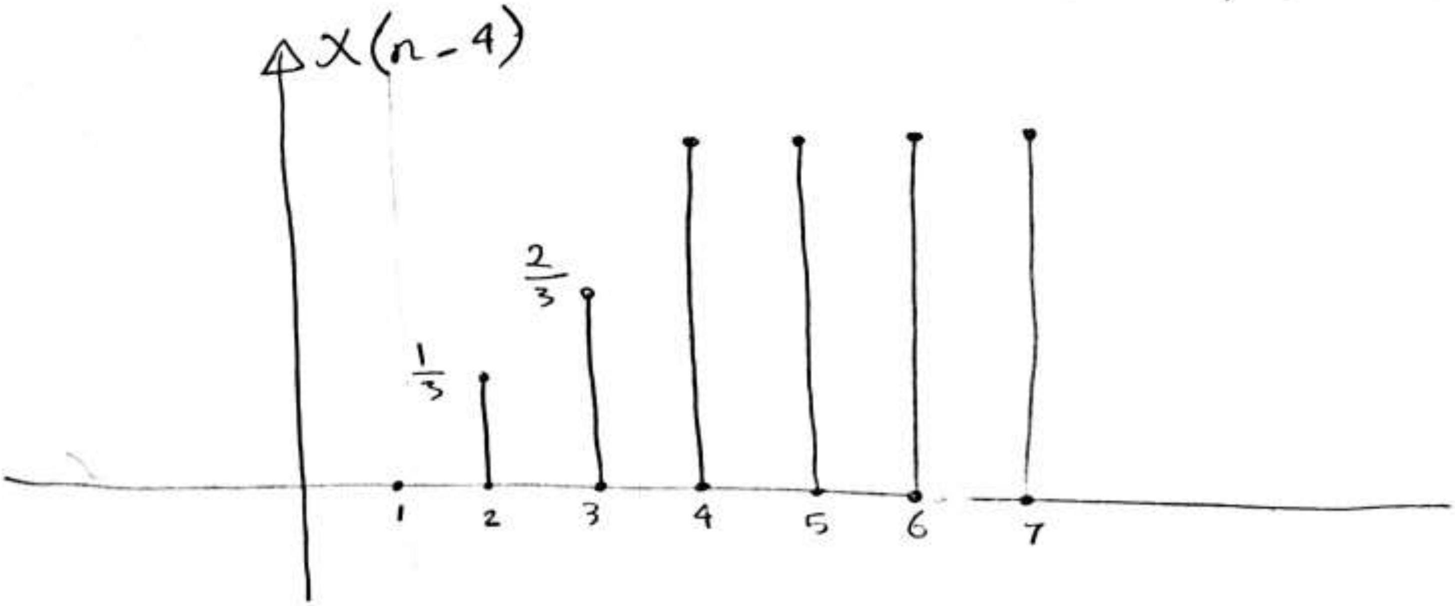
2) Fold $x(n)$



Delay by 4-samples.



إثبتها رياضياً



→ Delay by 4-sample

→ Then fold :-

$x(-n-4)$